Global Hydrology Resource Center

Data User Guide

GOES-R PLT Field Campaign Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG)

Introduction

The GOES-R PLT Field Campaign Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) dataset consists of radiance, reflectance, water phase, and navigation data collected by the Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) for the GOES-R Post Launch Test (PLT) field campaign. The GOES-R PLT field campaign took place from March to May of 2017 in support of post-launch L1B and L2+ product validation of the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). AVIRIS-NG is an imaging spectrometer that measures reflected radiance at 5 nm intervals in the Visible/Short-Wave Infrared (VSWIR) spectral range from 380-2,510 nm. AVIRIS-NG flew onboard the NASA ER-2 high-altitude aircraft during the GOES-R PLT field campaign. Data files in ASCII and BINARY formats are available for March 23 and 28, 2017.

Notice:
The ER-2 aircraft did not operate each day of the campaign; therefore, AVIRIS-NG data are only available on aircraft flight days.

Citation

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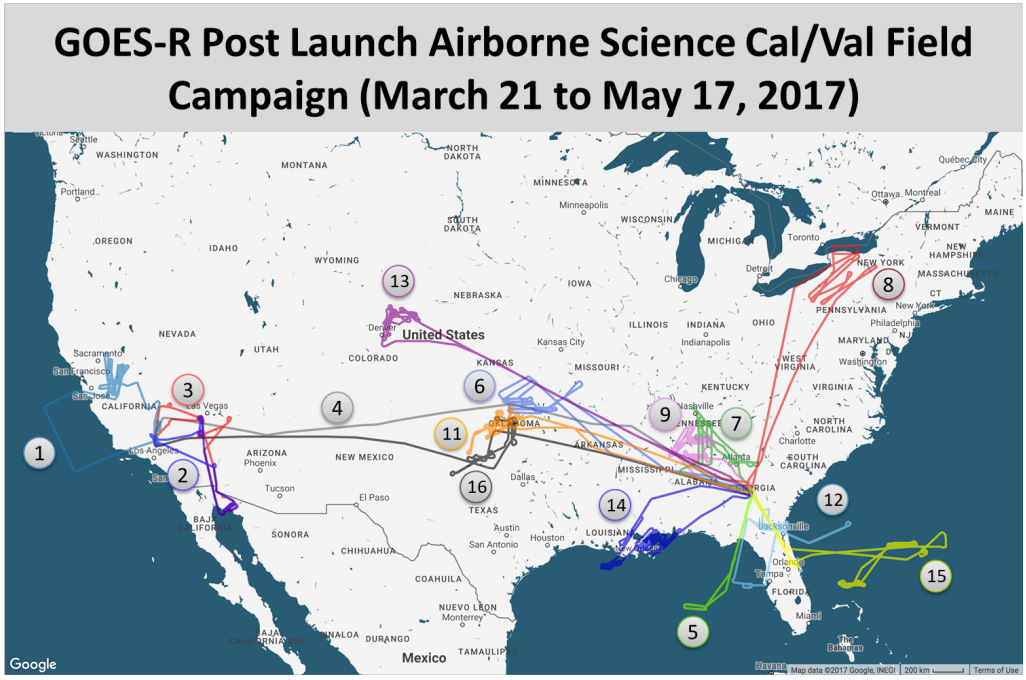
Keywords:

NASA, GHRC, NOAA, GOES-R, GOES-16, GOES-R PLT, ABI, GLM, AVIRIS-NG, ER-2

Campaign

The Geostationary Operational Environmental Satellites - R series (GOES-R) is a geostationary satellite program comprised of a four-satellite fleet including GOES-R, GOES-S, GOES-T, and GOES-U. The GOES-R Series Program is a collaborative development and acquisition effort between the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) to develop, launch and operate the satellites. The first satellite in the GOES-R series, GOES-R, launched on November 19, 2016 and became GOES-16 when it reached geostationary orbit. GOES-16 replaced GOES-13 as NOAA's operational GOES-East satellite at 75.2 degrees west longitude on December 18, 2017. GOES-16 observes North and South America, as well as the Atlantic Ocean all the way to the west coast of Africa. GOES-16 provides high spatial and temporal resolution imagery of the Earth using its Advanced Baseline Imager (ABI). GOES-16's Geostationary Lightning Mapper (GLM) is the first operational lightning mapper flown in geostationary orbit. GOES-16 also includes four other scientific instruments for monitoring space weather and the Sun. More information about the GOES-R mission can be found on the GOES-R website.

The GOES-R Post Launch Test (PLT) field campaign took place between March 21 and May 17, 2017 in support of the post-launch validation of NOAA's new generation of geostationary Earth-observing instruments: ABI and GLM. The campaign was comprised of two phases: the first centered on the U.S. west coast, providing tests primarily for the ABI instrument, and the second focused on the central and eastern U.S. with tests primarily for the GLM instrument (Figure 1). The validation effort included targeted data collections by the NASA ER-2 high-altitude aircraft coordinated with ground-based and low earth-orbit referenced data from several operational and research satellite missions. Dedicated ABI 30-second mesoscale (MESO) imagery collections were conducted concurrently with the ER-2 high-altitude aircraft based sensors during each GLM mission. The GOES-R PLT field campaign provided critical reference data and new insights into the performance NOAA's new generation of geostationary Earth-observing instrument products. More information about the GOES-R PLT field campaign is available on the GOES-16 Field Campaign webpage and the GOES-R PLT Field Campaign Micro Article.



*Flight #10 - April 27, 2017 - Huntsville, AL not shown due to aircraft navigation not reporting

Figure 1: The GOES-R PLT Field Campaign study area
(Image source: Frank Padula)

Instrument Description

The Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) is a passive remote sensing instrument that takes spectral measurements of the earth and atmosphere to extract information about surface and atmospheric features (Figure 2). AVIRIS-NG was flown aboard the NASA ER-2 high-altitude research aircraft during the GOES-R PLT field campaign. This instrument was developed as a replacement for the soon to retire Airborne Visible/Infrared Imaging Spectrometer - Classic (AVIRIS-C). The AVIRIS-NG has a higher signal-to-noise ratio than its predecessor so it gets greater precision and accuracy in its measurements. The new AVIRIS-NG has a higher spectral resolution at 5 nm compared to the 10 nm of the AVIRIS-C. It measures spectral radiance in 427 channels (AVIRIS-C 224 channels) with wavelengths ranging from 380 to 2,510 nm (AVIRIS-C 400 to 2,500 nm), within the visible and infrared portions of the electromagnetic spectrum. Spectra are measured as images with 600 cross-track elements. The AVIRIS-NG data from each channel reveal a spectrum of radiation. Analysis of the spectrum can reveal the type of feature and its characteristics. Each type of feature reflects a specific spectrum depending on its molecular composition. For example, the spectrum reflected by vegetation differs from that reflected by soil. AVIRIS-NG's scanning ability allows images to be constructed from these measurements. This information can be applied in various fields including environmental science, oceanography, land and water management, and agriculture. More information about the AVIRIS-NG instrument can be found at the NASA JPL AVIRIS-NG website. More information about remote sensing instruments and how they work can be found on the EOSDIS Remote Sensors webpage.

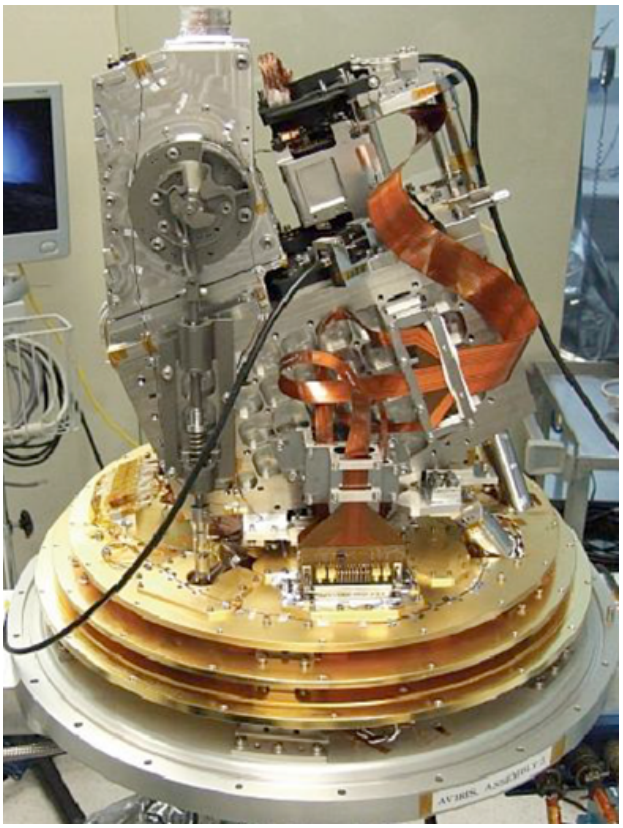


Figure 2: The AVIRIS-NG instrument
(Image source: JPL AVIRIS-NG Instrument webpage)

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Data Characteristics

The GOES-R PLT Field Campaign Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) dataset contains reflected radiance data in zipped BINARY and ASCII text files. These data are available at a Level 1B (L1B) and Level 2 (L2) processing level. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) aircraft
Instrument	Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG)
Spatial Coverage	N: 35.836, S: 31.206, E: -113.216, W: -121.489 (United States of America)

Spatial Resolution	18 m / pixel
Temporal Coverage	March 23, 2017 and March 28, 2017
Temporal Resolution	1 airborne flight run per file; multiple flight runs per day
Sampling Frequency	10 – 100 frames per second
Parameter	Radiance
Version	1
Processing Level	1B and 2

File Naming Convention

The GOES-R PLT Field Campaign Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) dataset consists of two versions of data: unortho-corrected (unortho) and ortho-corrected (ortho). An unortho image refers to raw aerial or satellite imagery. Ortho images have been processed to apply corrections for optical distortions from the sensor system, and apparent changes in the position of ground objects caused by the perspective of the sensor view angle and ground terrain. Therefore, an ortho image has all pixels in accurate (x,y) positions on the ground and thus can be used in a GIS.

(1) Ortho

The ortho data files, separated by processing levels (L1B and L2), are archived and compressed into *.tar.gz files. Users can extract *.tar.gz files using Linux command line "tar -xvf <file.tar.gz>" to access the data files. The naming conventions for each file type are listed below:

Ortho L1B compressed archive files: goesrplt_avng_<YYYYMMDD>t<hhmmss>.tar.gz
Ortho L1B data files: ang<YYYYMMDD>t<hhmmss>_rdn_<type>
ang<YYYYMMDD>t<hhmmss>_rdn_<type>.hdr

Ortho L2 compressed archive files: goesrplt_avng_<YYYYMMDD>t<hhmmss>rfl.tar.gz
Ortho L2 data files: ang<YYYYMMDD>t<hhmmss>_<type>
ang<YYYYMMDD>t<hhmmss>_<type>.hdr
Ortho L2 Readme file: ang<YYYYMMDD>t<hhmmss>_README_v2p5.txt

(2) Unortho

The unortho data files are also separated by processing levels (L1B and L2). The unortho versions have been binned and clipped, but not yet ortho-corrected. Apart from that, the descriptions and data units provided in the readme for the ortho-corrected versions also apply to the unortho versions. The naming conventions are listed below:

Unortho L1B data files: goesrplt_avng_<YYYYMMDD>t<hhmmss>_<type>
goesrplt_avng_<YYYYMMDD>t<hhmmss>_<type>.hdr
Unortho L2 data files: goesrplt_avng_<YYYYMMDD>t<hhmmss>_<type>
goesrplt_avng_<YYYYMMDD>t<hhmmss>_<type>.hdr

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year of flight run
MM	Two-digit month of flight run
DD	Two-digit day of flight run
hh	Two-digit hour at the start of acquisition in UTC
mm	Two-digit minute at the start of acquisition in UTC
ss	Two-digit second at the start of acquisition in UTC
v2p5	Processing version marker
<type>	File type (see Table 3)
.hdr	Image header file in ASCII format
.tar	TAR archive file
.gz	GNU zipped file

Table 3: AVIRIS-NG file type extensions

Extension	Description
glt	Geometric lookup table (Ortho+L1B)
igm	Input geometry file
loc	Pixel location data file (Unortho+L1B)
obs	Parameters relating to the geometry of observation and illumination in the raw spatial format (Unortho+L1B)
rdn_v2p5_clip	Radiance image file (Unortho+L1B)
corr_v2p5_clip	Scaled reflectance image file (Unortho+L2)
loc_ort	Pixel location data file rendered using the GLT lookup table (Ortho+L1B)
obs_ort	Parameters relating to the geometry of observation and illumination rendered using the GLT lookup table (Ortho+L1B)
corr_v2p5_img	Ortho-corrected, scaled reflectance image file (Ortho+L2)
h2o_v2p5_img	Ortho-corrected water absorption data (Ortho+L2)

Data Format and Parameters

The GOES-R PLT Field Campaign Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) dataset files are separated by processing level: L1B and L2. Files are in ASCII and binary format. Each file type is detailed below.
Note: The folder containing the L1B files is just labeled “L1”.

L1B Data Files

Header File for Geometric Lookup Table (*glt.hdr) data

This ASCII header file contains the format of the *glt file including the number of lines, samples, channel, integer format, pixel size, scene elevation, UTM zone number and rotation angle information, etc.

Geometric Lookup Table (*glt)
This BINARY file (32-bit signed long integer) is an ortho-corrected product with a fixed pixel size projected into a rotated Universal Transverse Mercator (UTM) system. It contains information about which original pixel occupies which output pixel in the final product. Additionally, each pixel is sign-coded to indicate if it is real (indicated by a positive value) or a nearest-neighbor infill (indicated by negative values).

Header file for Input Geometry File (*igm.hdr)
This ASCII header file contains the format of the *igm file including the number of lines, samples, channel, integer format, etc.

Input Geometry File (*igm)
This BINARY file (32-bit signed long integer) contains UTM ground locations (x, y, elevation) in meters for each pixel in the corresponding unortho-corrected radiance image. The IGM file data contain three parameters:

Table 4: UTM ground location parameters

Band	Description	Units
1	Easting	meters
2	Northing	meters
3	Estimated ground elevation at each pixel center	meters

No map correction or resampling is applied to the radiance image cube; the *igm file only reports the surface location of the unadjusted pixel centers.

Header file for calibrated Prism Radiance (Image) Data (*rdn_v2p5_clip.hdr)
This ASCII file contains the format of each PRISM L1B radiance scene including the number of lines, samples, channel, etc. It also records the spectral calibration (wavelength and full-width at half-maximum value) for every channel in the radiance data.

Calibrated Prism Radiance (Image) Data (*rdn_v2p5_clip)
This BINARY file (32-bit big-endian, floating point) contains PRISM L1B radiance in units of microwatts per centimeter squared per nanometer per steradian ($\mu W/cm^2 * nm * sr$).

Header file for pixel location data (*loc.hdr)
This ASCII file contains the format of each PRISM *loc file including the number of lines, samples, channel, etc.

Pixel Location Data (*loc)
This BINARY file (64-bit double-precision, floating point) contains pixel locations in World Geodetic System 1984 (WGS-84) format for each science pixel in the corresponding unortho-corrected radiance image. The *loc file data contain three parameters listed in Table 5 below.

Table 5: Pixel location parameters

Band	Description	Units
1	WGS-84 Longitude	degrees
2	WGS-84 Latitude	degrees
3	Estimated ground elevation at each pixel center	meters

Header file for Ortho-corrected pixel location data (*loc_ort.hdr)
This ASCII file contains the format of each PRISM *loc_ort file including the number of lines, samples, channel, etc.

Ortho-corrected Pixel Location Data (*loc_ort)
This BINARY file (64-bit double-precision, floating point) contains pixel locations in World Geodetic System 1984 (WGS-84) format for each science pixel in the corresponding ortho-corrected radiance image. The *loc_ort file data contain three parameters listed in Table 5.

Header file for observation parameter file (*obs.hdr)
This ASCII file contains the format of each PRISM *obs file including the number of lines, samples, channel, etc.

Observation Parameter File (*obs)
This BINARY file (64-bit double-precision, floating point) contains the observation parameters in raw spatial format and match the corresponding unortho-corrected radiance image. The eleven observation parameters are listed in Table 6 below.

Table 6: Observation parameters

Name	Description	Units
path length	Sensor-to-ground	meters
to-sensor-azimuth	0 to 360 degrees clockwise from North	degrees
to-sensor-zenith	0 to 90 degrees from zenith	degrees
to-sun-azimuth	0 to 360 degrees clockwise from North	degrees
to-sun-zenith	0 to 90 degrees from zenith	degrees
solar phase	Degrees between to-sensor and to-sun vectors in principal plane	degrees
slope	Local surface slope as derived from the Digital Elevation Model (DEM)	degrees
aspect	Local surface aspect 0 to 360 degrees clockwise from North	degrees
cosine i	Apparent local illumination factor based on DEM slope and aspect and to sun vector, -1 to 1	-
UTC time	Decimal hours for mid-line pixels	-
Earth-sun distance	Earth-sun distance in astronomical units	AU

Header file for Ortho-corrected observation parameter file (*obs_ort.hdr)
This ASCII file contains the format of each PRISM *obs_ort file including the number of lines, samples, channel, etc.

Ortho-corrected Observation Parameter File (*obs_ort)
This BINARY file (64-bit double-precision, floating point) contains observation parameters that have been rendered using the GLT lookup table and match the ortho-corrected imagery. The eleven parameters are listed in Table 6.

L2 Data Files

Header file for Calibrated AVIRIS Reflectance (Image) Data (*corr_v2p5_clip.hdr)
This ASCII header file contains the format of each AVIRIS-NG *corr_v2p5_clip file [unortho, calibrated radiance scene]. This includes the number of lines, samples, channel, etc. It also records the spectral calibration (wavelength and full-width at half-maximum values) for every channel in the radiance data. The "Smoothing factors" field contains a list of multiplicative coefficients applied to smooth the resulting reflectance spectrum. These coefficients were derived from Calibration measurements using spectrally-invariant surface targets. To remove this correction simply divide the apparent reflectance by these values.

Calibrated AVIRIS-NG Reflectance (Image) Data (*corr_v2p5_clip)
This BINARY file (32-bit little-endian, floating point) contains AVIRIS-NG unortho, calibrated reflectance in units of apparent surface reflectance (Gao et al., 1993).

Header file for Calibrated AVIRIS Reflectance (Image) Data (*corr_v2p5_img.hdr)
This ASCII header file contains the format of each AVIRIS-NG *corr_v2p5_img file [calibrated radiance scene]. This includes the number of lines, samples, channel, etc. It also records the spectral calibration (wavelength and full-width at half-maximum values) for every channel in the radiance data. The "Smoothing factors" field contains a list of multiplicative coefficients applied to smooth the resulting reflectance spectrum. These coefficients were derived from Calibration measurements using spectrally-invariant surface targets. To remove this correction simply divide the apparent reflectance by these values.

Calibrated AVIRIS-NG Reflectance (Image) Data (*corr_v2p5_img)
This BINARY file (32-bit little-endian, floating point) contains AVIRIS-NG calibrated reflectance in units of apparent surface reflectance (Gao et al., 1993).

Header File for Water Absorption Path (Image) Data (*h2o_v2p5_img.hdr)
This ASCII header file contains the format of each AVIRIS-NG *h2o_v2p5_img file including the number of lines, samples, channel, etc.

Water Absorption Path (Image) Data (*h2o_v2p5_img)
This BINARY file (32-bit little-endian, floating point) contains retrieved column water vapor and optical absorption paths for liquid water (H2O) and ice. The absorption parameters are listed in Table 7 below.

Table 7: Absorption path parameters

Band	Description	Units
1	Retrieved column H2O vapor	cm
2	Total liquid H2O absorption path	cm
3	Total ice absorption path	cm

Additional information about each file type is included in the AVIRIS-NG Data Product Distribution Document.

Algorithm

The radiance values collected by AVIRIS-NG are converted into surface reflectance using methods from the Atmosphere Removal Algorithm (Gao et al., 1993). This algorithm models absorption by various atmospheric constituents (water vapor, CO_2, oxygen, etc.) and combines these models with observation geometry to estimate atmospheric transmittance (the fraction of electromagnetic radiation transmitted through the atmosphere). From here, the algorithm goes on to estimate the apparent surface reflectance. More information about the AVIRIS-NG data processing is available in Bue, et al. 2015, Thompson et al., 2018 and the AVIRIS Surface Reflectance Processing and Products documentation.

Quality Assessment

The AVIRIS-NG image data were ortho-corrected to remove distortions caused by the viewing point of the sensor, terrain, and other factors. This correction was performed using three-dimensional ray tracing and a 30 m resolution DEM. This process gives the best estimate for the location and altitude of each image pixel. More information on the AVIRIS pixel correction procedure can be found in the AVIRIS Ortho-correction Processing and Production documentation.

Software

No software is required to view the AVIRIS-NG ASCII data files. They can be viewed in a text editor or in a spreadsheet software, such as Microsoft Excel or Notepad++.

A sample Python code is provided below to read longitude, latitude, and elevation values from a binary data file 'ang20170328t211047_rdn_loc'. The corresponding header file 'ang20170328t211047_rdn_loc.hdr' is needed as input, too. Users can modify this code to read data from other AVIRIS-NG binary files.

Sample Python code:

```
from numpy import memmap, array
import numpy as np
from spectral.io import envi
```

```
loc_file = 'ang20170328t211047_rdn_loc'
loc_meta = envi.read_envi_header(loc_file+'.hdr')
loc_shape = (int(loc_meta['lines']),int(loc_meta['samples']),int(loc_meta['bands']))
loc_mm = memmap(loc_file,shape=loc_shape,dtype='float64')
longitude = array(loc_mm[:,:,0])
latitude = array(loc_mm[:,:,1])
elevation = array(loc_mm[:,:,2])
```

Known Issues or Missing Data

The ER-2 aircraft did not operate each day of the campaign; therefore, AVIRIS-NG data are only available on aircraft flight days.

References

Bue, B.D., Thompson, D.R., Eastwood, M., Green, R.O., Gao, B., Keymeulen, D., ... Luong, H.H. (2015). Real-Time Atmospheric Correction of AVIRIS-NG Imagery. *IEEE Transactions on Geoscience and Remote Sensing*, *53(12)*, 6419-6428. https://dx.doi.org/10.1109/TGRS.2015.2439215

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Related Data

All data collected by other instruments during GOES-R PLT are considered related datasets. They can be located using the GHRC HyDRO2.0 search tool and entering the term 'GOES-R PLT' in the search box. The dataset collected by the AVIRIS-C instrument during the GOES-R PLT can be located by searching the term 'AVIRIS' in HyDRO2.0 and is linked below.

GOES-R PLT Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) dataset (http://dx.doi.org/10.5067/GOESRPLT/AVIRIS/DATA101)

Contact Information

To order these data or for further information, please contact:

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User Services
320 Sparkman Drive
Huntsville, AL 35805
Phone: 256-961-7932
E-mail: support-ghrc@earthdata.nasa.gov
Web: https://ghrc.nsstc.nasa.gov/

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